

GB2098491

Publication Title:

RESPIRATORY APPARATUS

Abstract:

Abstract not available for GB2098491

Abstract of corresponding document: US4519388

A respirator device particularly for use in association with a tube insertable into a person's trachea comprises a trachea tube having an inflatable cuff which seals the tube with the person's trachea. A line for ventilating gas extends into the tube and terminates in a jet nozzle directed to the trachea. The opposite end of the tube is provided with a connection to atmosphere which also makes it possible to provide a controlled vacuum pressure at this end particularly in the expiration phase. Control is effected between the ventilating gas and the vacuum for regulating the respiration. With the inventive method the vacuum is provided at the outer end of the trachea tube particularly during respiration and it is effected by directing a vacuum pressure gas supply connection through a Venturi connection to the tube which produces the vacuum in the tube and communicates the tube to atmosphere. This gas connection is controlled along with a ventilating pressure gas connection to provide the desired respiration.

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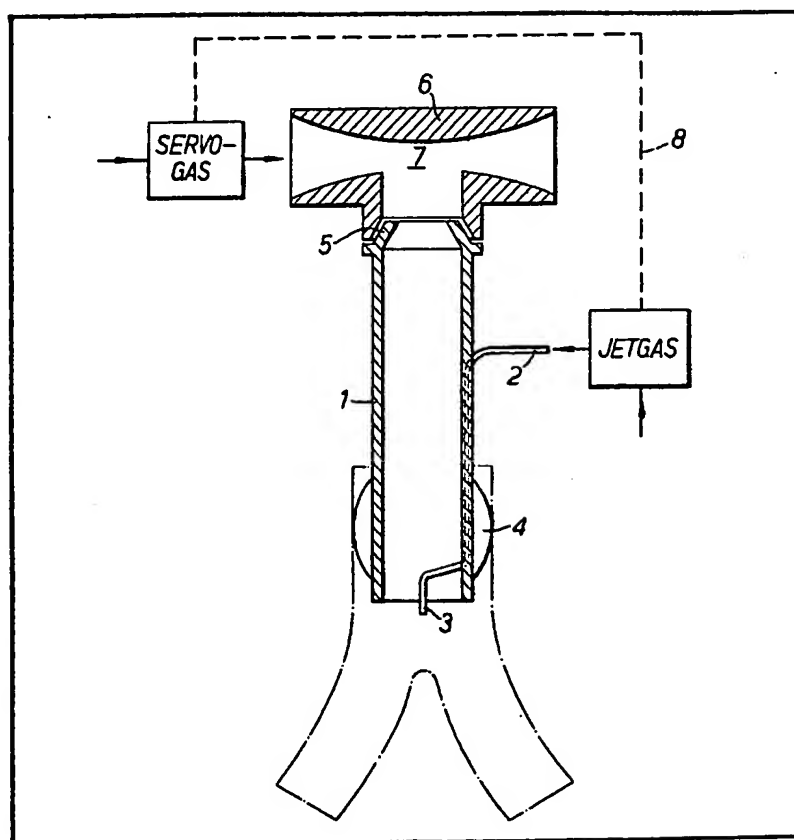
(12) UK Patent Application (19) GB (11) 2 098 491 A

(21) Application No 8202204
(22) Date of filing 26 Jan 1982
(30) Priority data
(31) 3119814
(32) 19 May 1981
(33) Fed. Rep. of Germany (DE)
(43) Application published
24 Nov 1982
(51) INT CL³
A61M 16/00
(52) Domestic classification
A5T AD
(56) Documents cited
GB A 2063686
GB A 2033759
GB A 2024021
GB 1447987
(58) Field of search
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A5R
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(54) Respiratory apparatus

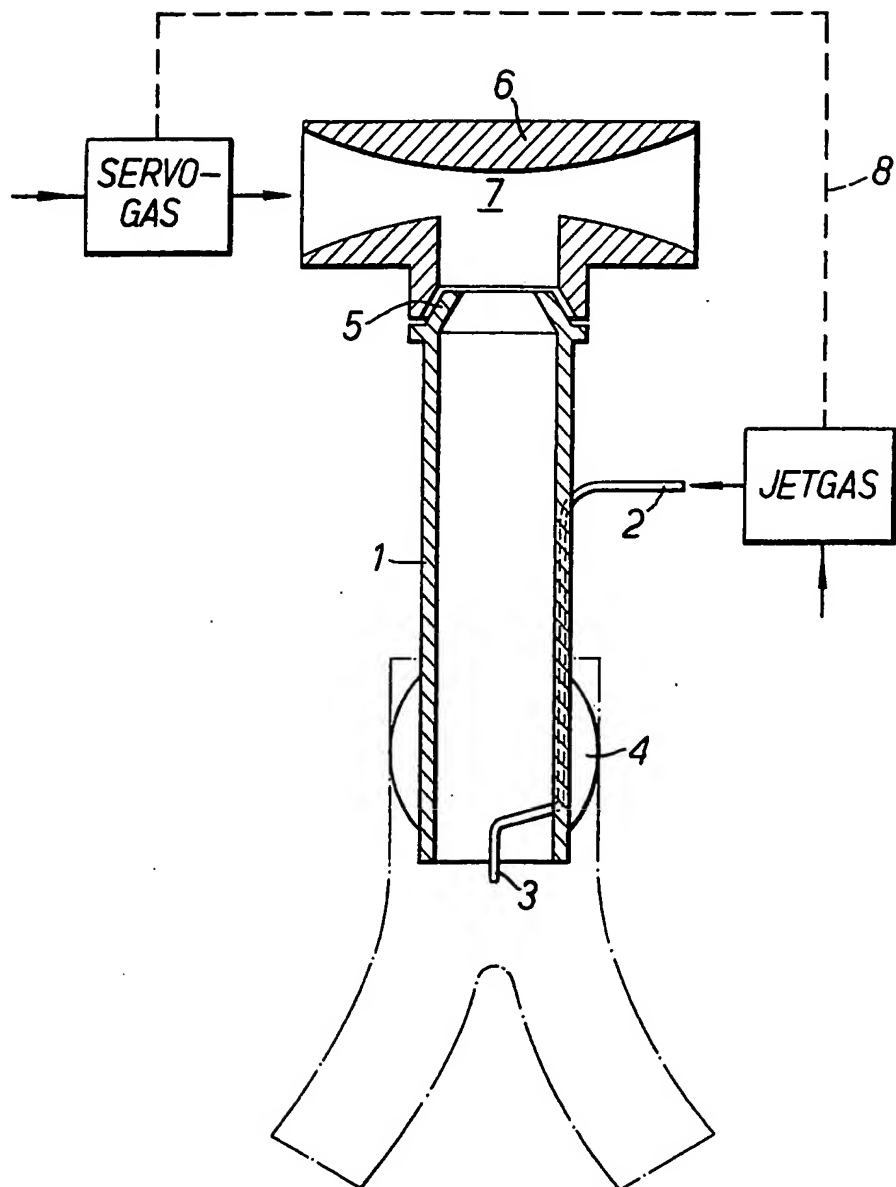
(57) A respiratory apparatus has an endotracheal tube (1) which includes at least one jet-nozzle (3) which opens adjacent a distal end region of the tube (1). A device (6) for producing subatmospheric and/or

superatmospheric pressure is connected, at least during exhalation phases, to a proximal end region (5) of the endotracheal tube (1). The device (6) is such that there is always communication between the interior of the endotracheal tube (1) and the atmosphere.



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SPECIFICATION

Respiratory apparatus

This invention relates to respiratory apparatus.

This invention more particularly, but not
 5 exclusively, relates to a respiratory apparatus with
 a respiratory gas source which can be controlled
 by means of a control apparatus and which
 supplies at least one jet nozzle, lying in the region
 10 of the distal end of an endotracheal tube, during
 the inhalation phase with high-pressure gas
 pulses having a frequency greater than the natural
 respiration rate, in particular a frequency greater
 than 300 pulses per minute. The control
 15 apparatus switches over to the exhalation phase
 at the end of the Inhalation phase. A prescribed
 pressure value, which deviates from the
 environmental atmosphere, can be adjusted at the
 proximal end of the endotracheal tube.

An alternating positive — negative pressure
 20 respiration (APB) can be effected with various
 known respiratory apparatus. According to the
 choice of the positive and negative respiratory
 pressures and the choice of the time phase
 relationship, the average respiratory pressure
 25 relative to atmospheric pressure can be
 maintained in the positive or negative range or
 approximately equal to zero.

An apparatus for alternating pressure
 respiration is described in German Patent
 30 Specification 916 727. With the aid of an injector,
 supplied with respiratory gas, the air is firstly
 drawn by suction out of the lungs until a
 corresponding sub-atmospheric pressure is
 reached. This subatmospheric pressure causes a
 35 reversal of the effect of the injector by means of
 control valves so that the gas, coming out of the
 injector, is now compressed into the lungs until it
 reaches a certain pressure value. The reversal
 between the respiratory phases is effected with
 40 the aid of a membrane-controlled valve, whose
 drive is provided by the difference in pressure,
 between a space, connected with the lungs, and
 the environmental atmosphere.

Our British Patent Application 8035781
 45 describes a respiratory method with a respiratory
 gas source which can be controlled by patient
 data by means of a control apparatus and this
 method can be operated with an endotracheal
 tube or an insufflation catheter with a jet nozzle,
 50 whereby the respiratory gas source produces, in
 the case of HFJV (high frequency jet ventilation)
 drive, high-pressure gas pulses, which form a
 series of respiratory pulses and leave intervals
 free for exhalation between these series of
 55 respiratory pulses. A prescribed pressure value,
 which deviates from the ambient pressure, can be
 set at the proximal end of the tracheal tube by
 means of a closing element.

According to the present invention, there is
 60 provided a respiratory apparatus comprising: an
 endotracheal tube including at least one jet-
 nozzle which opens adjacent a distal end region of
 the tube and intended for insertion into a trachea;
 and a device for producing a subatmospheric

65 and/or superatmospheric pressure which device,
 at least during exhalation phases, is connected to
 the proximal end region of the endotracheal tube
 and which, in use, is such that nevertheless there
 is always communication between the interior of
 70 the endotracheal tube and the atmosphere.

The respiratory apparatus advantageously
 includes a control unit, for controlling the supply
 of respiratory gas to the jet-nozzle(s).

The control unit is preferably such that, during
 75 each inhalation phase, high pressure gas pulses
 are supplied to the or each jet nozzle at a rate
 greater than the natural respiratory frequency,
 and at the end of each inhalation phase the
 control unit switches to an exhalation phase. The
 80 respiratory apparatus can include a source of
 respiratory gas connected via the control unit to
 the jet-nozzle(s) of the endotracheal tube.

The respiratory apparatus of the present
 invention should enable the effectiveness of HFJV
 85 to be improved during the expiration phase and in
 particular should allow complete exhalation of the
 CO₂ produced. It should also impeded spontaneous
 respiration or sudden bursts of coughing and the
 like as little as possible. The respiratory apparatus
 90 should enable free deep breathing to occur at any
 time, that is in the inhalation phase and in the
 exhalation phase. Consequently, bursts of
 coughing can be suppressed directly so that
 Barotrauma is prevented. In addition, an essential
 95 improvement of the HFJV can be achieved
 through the subatmospheric pressure applied in
 the exhalation phase in that the CO₂ obtained at
 an increased rate, especially in the case of a high
 metabolic rate, can be removed by suction more
 100 successfully by increasing the variation in
 pressure between the alveolar space of the lungs
 and the other end of the tracheal tube.

Although the endotracheal tube should be
 connected with the device for producing
 subatmospheric pressure, at least in the
 105 exhalation phase, it can be advantageous, if
 necessary, to maintain this connection in the
 inhalation and exhalation phases. The
 effectiveness of a high frequency respiration
 process is determined above all by the possibility
 of removing the carbon dioxide from the lungs. In
 the terminal bronchial zones the elimination of
 carbon dioxide takes place mainly through
 diffusion and is thereby dependent upon the
 115 length of the diffusion paths.

By applying subatmospheric pressure in the
 inhalation and exhalation phases a state of
 inflation of the lungs can be achieved in which the
 diffusion paths are shortened in a desirable way.

The level of the subatmospheric pressure
 produced by the device can, advantageously, be
 adjustable. It is advantageous, if, in use, the
 control unit controls said device so that the
 subatmospheric pressure produced is adjusted in
 120 dependence upon the quantity of respiratory gas
 supplied to the jet-nozzle, the subatmospheric
 pressure being decreased as the quantity of
 respiratory gas is increased.

Preferably, the device for producing

subatmospheric pressure is capable of producing subatmospheric pulses at rates in the range from 10 pulses per minute to 1,000 pulses per minute. The length of these subatmospheric pulses can, advantageously, lie between 1 ms and 250 ms whereby the subatmospheric pressure is fixed somewhere in a region between 2 and 25 millibars.

Advantageously the subatmospheric pulses are synchronized with the high pressure gas pulses by the control unit in such a way that at least one subatmospheric pulses always follows a high pressure gas pulse or a series of high pressure pulses.

Preferably, the device is intended to produce subatmospheric pressure, and comprises a venturi nozzle supplied with gas from a source of servo gas, the venturi nozzle being connected to the proximal end region of the tracheal tube. The flow of servo gas determines the subatmospheric pressure in the endotracheal tube. The venturi nozzle is advantageously provided in an auxiliary attachment which can be attached on to the endotracheal tube. The cross-section of a suction connection between the endotracheal tube and the venturi nozzle and the free flow cross-section of the venturi nozzle correspond, at least approximately, to the free flow cross-section of the tracheal tube.

Instead of a venturi nozzle, other known apparatus can be used, if necessary, to produce a subatmospheric pressure, for example nozzle arrangements, similar to injectors, which are also supplied from a servo gas source and make free deep breathing possible.

For a better understanding of the present invention and to show more clearly how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawing which shows a partial section through an apparatus according to the present invention.

An endotracheal tube 1, which includes, in its wall a supply line 2 for the respiratory gas (jet gas). This supply line 2 opens into a single jet-nozzle 3 as shown or into separate jet-nozzles separate from one another for each lung. For sealing purposes with respect to the trachea, there is provided an inflatable collar 4 on the exterior of the endotracheal tube 1.

An extension member 6 is attached to a conical, proximal end portion 5 of the endotracheal tube 1. The free cross-section of apertures or openings in either end face of the extension member 6 correspond approximately the free cross-section of the endotracheal tube 1. A venturi nozzle 7 is formed in a narrow portion or throat of the extension member 6 and its axis is perpendicular to the endotracheal tube 1.

For the controlled production of subatmospheric pressure, pressurised gas is supplied to the venturi nozzle 7 from a source of servogas, so that a corresponding subatmospheric pressure results inside the endotracheal tube 1.

In the inhalation phase, the respiratory gas is

supplied to the jet-nozzle 3 in the form of high-pressure gas pulses from a jet gas source via the supply line 2. The control apparatus for the jet gas source are connected by a synchronizing line 8. A situation can be reached thereby, where the level of the subatmospheric pressure is adjusted to the quantity of respiratory gas supplied through the jet-nozzle 3. Alternatively, when a series of high pressure gas pulses is always followed by a corresponding subatmospheric pressure section of the exhalation phase or a series of subatmospheric pulses, the series of high pressure pulses can be synchronised with the series of subatmospheric pressure pulses or the subatmospheric pressure section of the exhalation phase.

Claims

1. A respiratory apparatus comprising: an endotracheal tube including at least one jet-nozzle which opens adjacent a distal end region of the tube and intended for insertion into a trachea; and a device for producing a subatmospheric and/or a superatmospheric pressure which device, at least during exhalation phases, is connected to the proximal end region of the endotracheal tube and which, in use, is such that nevertheless there is always communication between the interior of the endotracheal tube and the atmosphere.

2. A respiratory apparatus as claimed in claim 1, which includes a control unit, for controlling the supply of respiratory gas to the jet-nozzle(s).

3. A respiratory apparatus as claimed in claim 2, wherein the control unit is such that, during each inhalation phase, high pressure gas pulses are supplied to the or each jet-nozzle at a rate greater than the natural respiratory frequency, and at the end of each inhalation phase the control unit switches to an exhalation phase.

4. A respiratory apparatus as claimed in claim 3, wherein the control unit is such that, during each inhalation phase, high pressure gas pulses are supplied to the jet-nozzle(s) at a rate greater than 300 pulses per minute.

5. A respiratory apparatus as claimed in claim 2, 3 or 4, which includes a source of respiratory gas connected via the control unit to the jet-nozzle(s) of the endotracheal tube.

6. A respiratory apparatus as claimed in any preceding claim, wherein said device can produce a subatmospheric pressure which can be adjusted to a desired value.

7. A respiratory apparatus as claimed in claim 6 when appendant to claim 2, wherein, in use, the control unit controls said device so that the subatmospheric pressure produced is adjusted in dependence upon the quantity of respirator gas supplied to the jet-nozzle(s) the subatmospheric pressure being decreased as the quantity of respiratory gas is increased.

8. A respiratory apparatus as claimed in any preceding claim, which is such that, in use, the subatmospheric pressure is applied to the endotracheal tube in exhalation phases only.

9. A respiratory apparatus as claimed in any

preceding claim, wherein said device is capable of producing subatmospheric pulses at rates in the range from 10 pulses per minute to 1000 pulses per minute.

5 10. A respiratory apparatus as claimed in claim 9 when appendant to claim 3, wherein the apparatus is such that, in use, the subatmospheric pulses are synchronized with the high pressure gas pulses by the control unit in such a way that
10 at least one subatmospheric pulse always follows a high pressure gas pulse or a series of high pressure pulses.

15 11. A respiratory apparatus as claimed in any preceding claim, wherein said device is intended to produce a subatmospheric pressure and comprises a venturi nozzle supplied with gas from a source of servo gas, the venturi nozzle being
connected to the proximal end region of the

endotracheal tube.

20 12. A respiratory apparatus as claimed in claim 11, wherein the venturi nozzle is disposed transversely of the endotracheal tube.

25 13. A respiratory apparatus as claimed in claim 11 or 12, wherein a free flow cross-section of a suction connection between the endotracheal tube and the venturi nozzle and the free flow cross-section of the venturi nozzle correspond, at least approximately, to the free flow cross-section of the endotracheal tube.

30 14. A respiratory apparatus as claimed in claim 11, 12 or 13, wherein the venturi nozzle is provided in an attachment which can be attached to the endotracheal tube.

35 15. A respiratory apparatus substantially as hereinbefore described with reference to, and as shown in, the accompanying drawing.